Module 7 - Time Varying Circuits

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering

Tennessee Technological University

Topic 2 - First Order Systems

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- General System Model
- Mechanical-Electrical Analogies
- Example: RC Circuit
- Example: Bulb Thermometer

General System Model

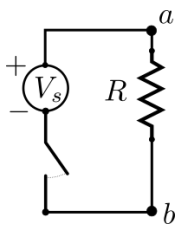
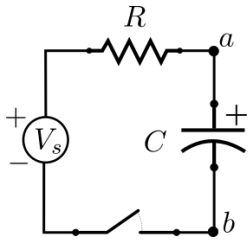
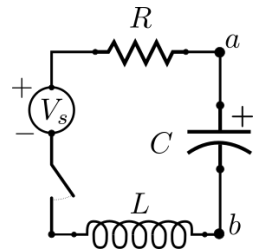
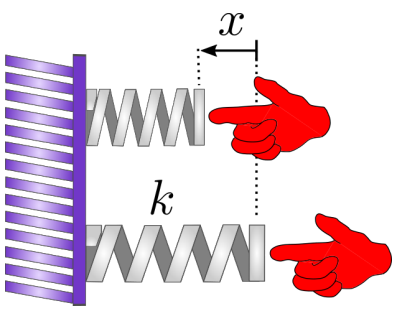
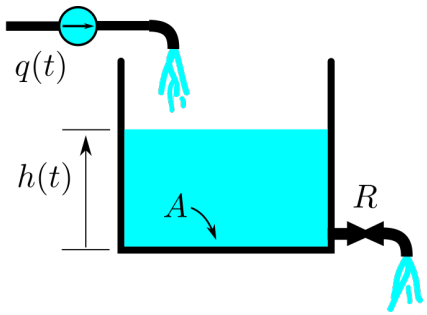
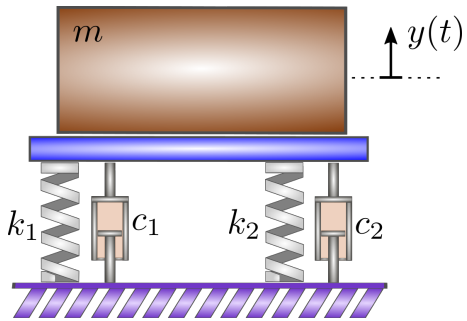
The behavior of a circuit is dependent on time, and many common circuits can be represented by a *linear ordinary differential equation* which can be written in the following standard form.

$$a_n \frac{d^n x}{dt^n} + a_{n-1} \frac{d^{n-1} x}{dt^{n-1}} + \ldots + a_2 \frac{d^2 x}{dt^2} + a_1 \frac{dx}{dt} + a_0 x = f(t)$$

General System Model

Mechanical-Electrical Analogies

Many mechanical systems are also time dependent, or *dynamic* and a mechanical-electrical analog is often draw between the two.

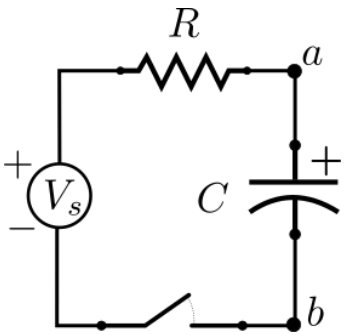
Zero Order	First Order	Second Order
		
		

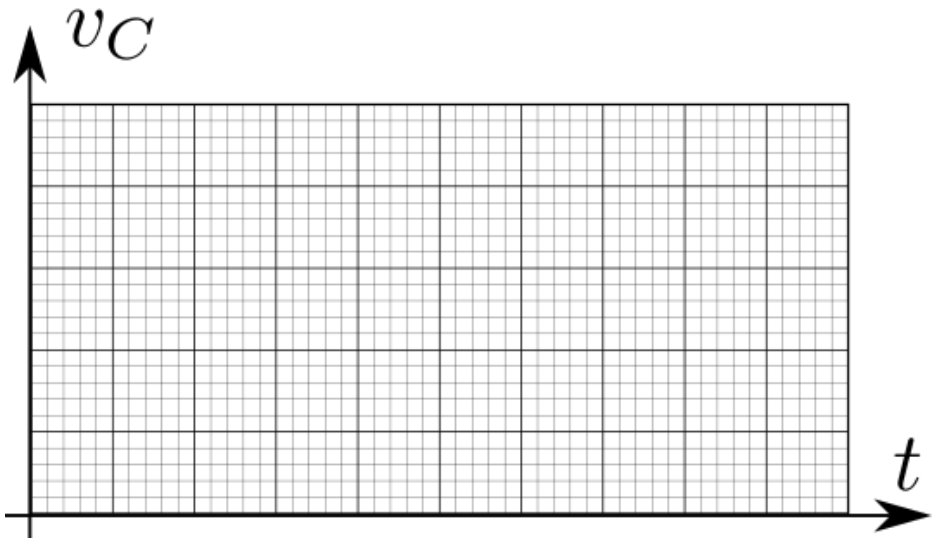
This concept *was* used for analysis and simulation.

Mechanical-Electrical Analogies

Example: RC Circuit

The RC circuit is a first order system. The response to a step input v_s is exponential which is decscribed a single parameter the time constant τ.



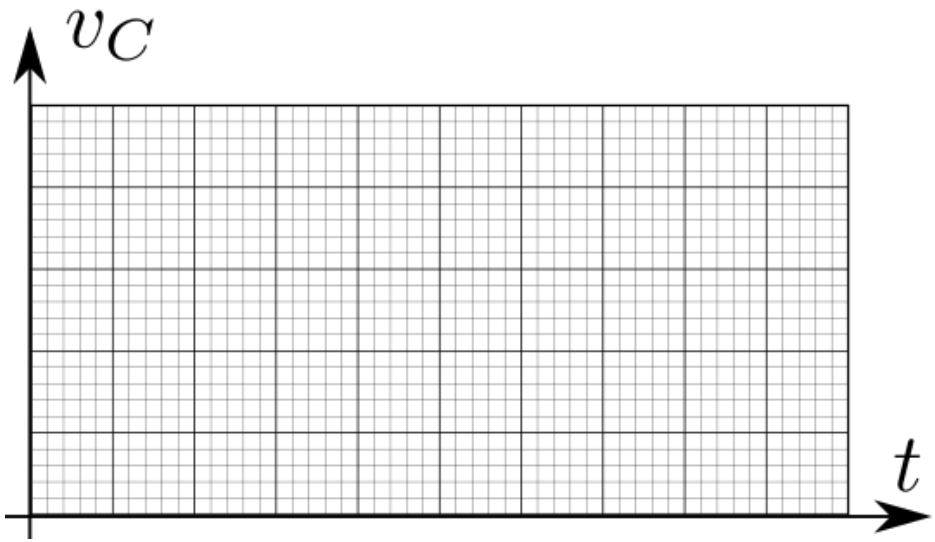


$$RC\dot{v}_C + v_C = v_S$$

$$v_C(t) = v_s\left(1 - e^{-\frac{t}{RC}}\right)$$

Example: RC Circuit

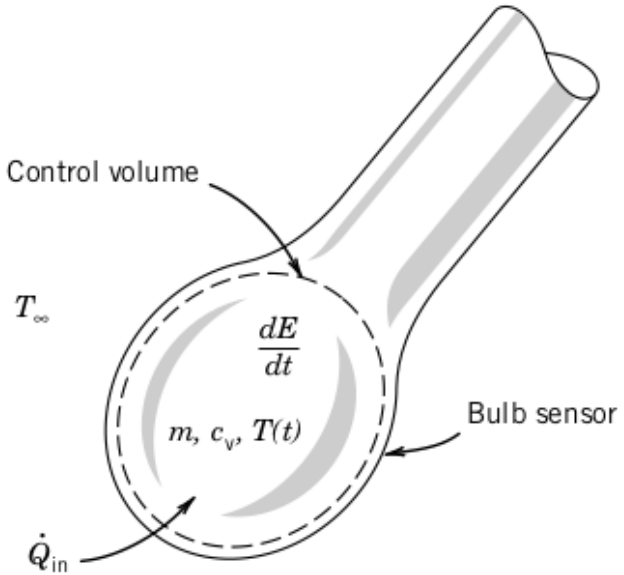
time, $t(s)$	*response*, v_C(V)



Example: Bulb Thermometer

Consider the bulb thermometer shown which can be modeled as a first order system. If the system was intially at T0

$$\frac{dE}{dt} = \dot{Q}$$



Example: Bulb Thermometer